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USSR STUDY OF THE INFLUENCE OF DEFECTS IN THE FORM OF BORED HOLES ON THE VALUE OF IMPACT STRENGTH OF METAL

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Impact tests of notched samples of metal in addition to determining the cold shortness of metal, also reveal nonmetallic inclusions, microporosity, etc. Along with these small defects, separate greater defects could also be found in the metal. The effect on the value of impact strength will vary depending on the position of the defect. To investigate this subject experimentally, we used impact specimens of various steels with defects in the form of differently oriented bored holes 2 millimeters in diameter.

The tests were conducted on a 15-kilogram Amsler-type impact machine manufactured by GIZP. The results are given in Table 1.

Table 1. Test Results on Impact Specimens of Various Steels with Bores Variously Oriented (average for five samples)

Impact Strength (kg/sq cm)

Type of Specimen	Steel 45 $H_B = 190$	Steel 40KhS $H_B = 445$	Steel 18 KhN4VA $H_B = 320$	Steel 38 KhA $H_B = 320$	Steel 38 KhA $H_B = 475$
1. Standard specimen with Menazhe notches	5.10	3.80	13.90	14.40	4.10
2. Specimens with single hole perpendicular to the notch	3.90	3.20	10.75	10.90	2.40

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3. Specimens with two holes perpendicular to the notch	4.50	3.15	----	----	----
4. Specimens with single hole parallel to the notch	6.90	4.90	12.30	12.60	3.70
5. Specimens consisting of two parts 5 mm wide	6.20	4.55	13.90	14.90	4.80

As is clear from Table 1, the impact strength of steels 45 and 40 KhS with holes parallel to the notch was increased, while that of 18 KhN4VA and 38 KhA was lowered. The bores perpendicular to the notch lowered the impact strength in all cases.

Composite samples of two halves each 5 millimeters wide in Four cases out of **Five** showed a somewhat higher impact value. In one case (samples of 18 KhN4VA steel), the impact value was the same as that in the normal specimen.

A lowering of the impact value by holes perpendicular to the notch is found to contradict Bauman's results. (This and other data is taken from N. N. Davidenkov's Dinamicheskiye ispytaniya metallov, 1936.)

An increase in the impact value of the bored specimens in Bauman's tests, as in the composite specimens of our tests, corresponds to Moser's results. Moser found that, by increasing the width of the samples, the specific impact strength was decreased as well as the absolute value of the impact strength. According to N. N. Davidenkov, with increase in the width of the specimen, the volume-stressed state is increased in the center part of the notch, which leads to the appearance of more brittle fractures and to lowering the impact value. But the reduction of impact value in bored specimens cannot be explained in this manner. To clarify this we conducted special tests for the purpose of answering the following questions:

1. What is the relationship between impact values used on the deformation and on the proper breaking of the specimen?

2. What is the effect of the limitation of deformation in specimens on the total value of impact strength for materials with sharply differing impact strength values:

3. What is the effect of width in a specimen made of very plastic material, in which a very significant increase in the width does not bring about the appearande of brittleness in the fractures?

To answer the first question, a series of specimens of 38 KhMYuA with a hardness of 300 H_B was prepared. These samples underwent impact tests with various rises of the pendulum hammer. The following results were obtained: (1) specimens which absorbed 9 kilogram-meters of work were strongly deformed but remained intact; (2) after 9.5 kilogram-meters of work were absorbed, a small crack appeared; (3) the specimens were broken after 10.5 kilogram-meters work.

To determine the influence of limiting the possibility of deformation on the impact value, standard specimens were tested as well as those that were notched on the sides. The notches on the sides limited the possibility of deformation of the specimens, since in the notched specimens the stresses in the cross section not affected by the notches were considerably lower than those in the cross section of the notch, and did not reach a value sufficient for plastic deformation. The cross section of the notch in specimens notched on the sides remained, as in the standard samples, equal to 8 by 10 millimeters. The results obtained are given in Table 2.

Table 2. Comparative Results of Testing Standard Specimens and Notched Side Specimens of Various Materials (average for three specimens)

Material	Brinell Hardness (kg/sq mm)	Impact Strength (kg/sq cm): Standard Specimens	Impact Strength (kg/sq cm): Specimens with Notched Sides
18 KhN4VA Steel	320	13.9	6.6
45 steel	190	5.4	3.4
40 KhS steel	270	2.2	1.1
Cast iron	170	0.16	0.16
Duralumin	90	2.2	1.25

Table 2 demonstrates that limitation of deformation has an approximately similar effect on such different materials as duralumin, 18 KhN4VA steel, 40 KhS steel, and 45 steel. The only exception, represented by cast iron, is easy to understand since additional limitation modifies very little the deformity limitation already created in cast iron by graphite inclusions.

Determination of the width effect in specimens made of high-plastic 18 KhN4VA steel was conducted with specimens varying in width from 2.5 to 25 millimeters. The results obtained are given in Table 3.

Table 3. Results of Testing Impact Specimens of Various Width — 18 KhN4VA Steel with a Hardness 300 H_B (average for Five Specimens)

Width of Specimen (mm)	Impact Strength (kg/sq cm)
2.5	13.0
5.0	13.7
10.0	12.9
15.0	13.1
20.0	12.6
25.0	13.4

As is clear from Table 3, the width of a specimen prepared from such a plastic material as 18 KhN4VA does not play any essential role since, even at a width of 25 millimeters, no brittle portions of fracture surface were observed.

From the general results of the three experiments, the following conclusions can be drawn. Boring, like other defects, changes the impact strength in two ways. First, by weakening the cross section in some places, boring assists the concentration of the deformation in one, not very great, part of the specimen and decreases the impact value. This decrease is very important since 90 percent of the energy used in breaking the sample is expended in the deformation process. It must also be noticed that this decrease affects in an approximately similar way specimens made of different materials. On the other hand, boring defects perpendicular to the notch decrease the volume-stressed state and, in this case, act similarly to decreasing the specimen width. But the width of the specimen substantially influences only materials with semibrittle fractures and does not generally affect such plastic materials as 18 KhN4VA steel.

To substantiate these assumptions, specimens made of 45 steel with bored holes of various diameters were tested. This steel demonstrated its sensitivity to boring as well as to width. It could be expected that, with a bore diameter less than the width of the notch, the impact strength decrease would be very considerable due to the limited area of deformation area, and decreasing the volume-stressed state will raise the impact strength.

As is clear from Table 4, with an increase in the diameter of the bore, there is an increase in impact strength. However, it does not reach the impact value which was obtained for a specimen without bored holes.

Table 4. Results of Testing Samples with Bores of Various Diameters Perpendicular to the Notch (Steel 45 with a hardness 225 H_B (average for Five specimens))

Diameter of Bore (mm)	Impact Strength (kg/sq cm)
Specimen without bored holes	9.7
1.0	6.5
2.0	6.8
3.0	7.1
4.0	8.2

The fractures of these specimens are also interesting. It appears that the greater the bore diameter, the smaller the area of coarsely crystalline fracture.

In summarizing, the following conclusions can be made. Defects and borings, if distributed in the specimen in a way which decreases the deformation volume, always lower the impact value. This decrease is greater as boring and defects decrease the deformation volume, and appears approximately similar in various materials (cast iron and materials similar to it are excluded). In the case of materials with semibrittle fractures, borings and other defects can bring about some increase in the impact strength if they are located in such a way as to lower the volume-stressed state, acting as would a decrease in width. Such was probably the case in Bauman's experiments.

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